Computer-Supported Collaborative Learning
DOI 10.1007/s11412-011-9139-3

4SPPIces: A case study of factors in a scripted collaborative-learning blended course across spatial locations

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Received: 8 February 2011 / Accepted: 29 December 2011

Abstract Computer-Supported Collaborative Blended Learning (CSCBL) scripts are complex learning situations in which formal and informal activities happening in different spatial locations are coordinated and integrated into one unique learning setting through the use of technology. We define a conceptual model identifying four factors to be considered when addressing the design of these CSCBL scripts and of the technological system for supporting their enactment: the space, the pedagogical method, the participants and the history (4SPPIces factors). This paper presents and evaluates a CSCBL script designed according to the 4SPPIces factors. The script is proposed for extending the learning of geographic fieldwork in a geography course at a high school. In this script, students reflect about the urbanism and the socio-geographic characteristics of a Barcelona neighborhood. The script blends individual and collaborative activities supported by mobile and computer-based technologies conducted in the classroom, home and city. The script is evaluated in a case study involving 34 students and two teachers. The case study reports: (1) the CSCBL script designed with the teachers, considering the 4SPPIces factors and the associated technological environment and (2) the results of enacting the script in the actual learning context and analysing whether it fulfils the targeted learning objectives. The results from this case study show the impact of considering the 4SPPIces factors to enhance a real practice providing new learning and motivational benefits. The CSCBL script presented is an example that can encourage other practitioners and researchers to adopt the 4SPPices factors in similar educational situations.

Electronic supplementary material The online version of this article (doi:10.1007/s11412-011-9139-3) contains supplementary material, which is available to authorized users.

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Keywords Computer supported collaborative learning script · Blended learning · Educational spaces · Mobile learning · Case study

In recent years, devices such as mobile phones or PDAs combined with wireless connectivity are changing the nature of educational practices. Now learners are not at a fixed predetermined location and can move across different spaces. Collaborative learning can occur both in and beyond the classroom. Furthermore, formal activities with other actions that have been traditionally informal can be monitored and orchestrated across spatial locations, leading to new types of collaborative-blended-learning practices (CBL) (Roschelle 2003; Kukulska-Hulme and Traxler 2005; Kurti et al. 2008; Spikol and Milrad 2008; Roschelle et al. 2010).

The study by Facer et al. (2004) is an example of these CBL practices. This study proposes using mobile phones for supporting a collaborative experience in which children are invited to understand the animal behavior in a savannah in direct physical interaction with space. The results show that, despite its complexity, the experience fostered students' motivation and helped in the acquisition of concepts. In another study by Ruchter et al. (2009) mobile devices are used by a group of users as a guide for supporting environmental learning. The conclusions of this study showed that using mobiles leads to an increase in students' environmental knowledge and in their motivation in environmental education activities. Also, work by Lim (2006) suggests that using mobile phones as a tool for collaborative learning around two geographical tasks augments spatial intelligence and mapping skills.

The main interest of these CBL practices falls on their blended nature and their innovation in terms of technology usage and learning benefits. But, what makes these practices especially interesting for learning is that the use of technology is always driven by educational considerations. That is to say, the technologies employed are selected not only for the functionalities that they offer but also for the way in which their functionalities effectively support and enhance the learning purposes.

One of the major difficulties of CBL practices when enacted in actual educational context relies on coordinating and monitoring the different activities so as to produce effective collaboration. CSCL scripts (Stahl 2005; Dillenbourg & Fischer, 2007) are a well-know solution for technologically coordinating (or orchestrating) collaborative learning so as to lead to situations of effective learning. In the context of this paper and by analogy with CSCL scripts, we refer to CSCBL scripts as the means for coordinating a CBL practice. CSCBL scripts can therefore be defined as a type of CSCL scripts for supporting the coordination of collaborative practices that combine formal and informal activities occurring across different spatial locations.

Because of their multidisciplinary nature, the design of CSCL scripts and of the applications for their support implies a balance between technology and education (Larusson & Alterman, 2009). But to keep this balance is even more complex when facing the design of CSCBL scripts (Park et al. 2010). New factors such as the spatial locations and the interplay between formal and informal activities have direct implications on the way collaboration is organized that have to be understood from both educational and technological perspectives.

Designing potentially effective CSCBL scripts requires the intervention and the mutual understanding of two different actors: practitioners (experts in educational issues) and technicians or technologists (aware of the technologies available and their potential) (Dimitriadis et al. 2003). Both practitioners and technicians have to work hand in hand to end up with meaningful CSCBL scripts and educationally driven technological environments for effectively supporting their enactment.

4SPPIces is a conceptual model for supporting communication between practitioners and technicians when facing the design of CSCBL scripts and of the technological environment

supporting their enactment. 4SPPIces considers four factors: the Space, the Pedagogical Method, the Participants and the History. These 4SPPIces factors constitute a framework that yields insights into the complexity of CSCBL scripts for facilitating a conceptualization of the elements that describe them and which have to be considered in their design.

This paper presents the results of an illustrative case study of a CSCBL script in which the 4SPPIces factors are enacted in a real situation with two teachers and 34 students. Specifically, the CSCBL script is proposed to solve the limitations of a fieldwork activity framed in a geography course that occurs every year at a high school, Duc de Montblanc of Rubí (a town close to Barcelona). The activity consists of a visit to Barcelona to foster students' familiarization with the urbanism and the socio-geographical characteristics of the different districts of the city. The two teachers involved in the geography course listed the limitations about the past editions of the activity: (1) The activity is programmed to spend one morning in the city, which constrains the visit to only one area in Barcelona hindering comparisons of different districts in the city; (2) The visit is prepared as an individual activity but teachers were interested in introducing a collaborative component to promote students' competencies of working in groups and critical thinking; and (3) Teachers are interested in using Information and Communication Technologies (ICT) to adapt to the new curriculum (see Catalan High School Curriculum).

The main research question addressed in this case study is: *Does considering the 4SPPIces factors help practitioners and technicians in the design of a meaningful CSCBL script for extending an actual geography fieldwork to overcome the limitations detected its previous editions?* Specifically, two research questions derived from the main question were analyzed: (1) Does the CSCBL script, considering the 4SPPIces factors, cover the demands of the teacher for the specific geography context? and (2) Does the technological environment associated to the CSCBL script supports students' and teachers' tasks? The results of this case study show the effects of considering the 4SPPIces factors for improving a real educational situation.

In the next section, the 4SPPIces model is presented to provide the context of the case study and the main research objectives that will be addressed. The next next section describes the methods and analytical strategies used for evaluating the CSCBL script. First, we report the CSCBL script designed with the practitioners. Second, we describe the results of running the CSCBL script. The final section discusses how the results of the case study provide answers to the research questions and draws conclusions concerning the benefits of considering the 4SPPIces factors to design suitable and meaningful CSCBL scripts.

4SPPIces: A model for designing CSCBL scripts

4SPPIces is a conceptual model that provides practitioners and technicians with a common language to design CSCBL scripts and the technological setting for supporting their enactment. 4SPPIces combines four factors for the design of CSCBL scripts: the Space, the Pedagogical method, the Participants and the History. These factors have been studied separately in the literature, with special emphasis on the pedagogical method and the participants. The novelty of 4SPPIces falls on: (1) combining these factors into one unique representation, (2) explicitly defining the space as a relevant factor to be considered during the design and (3) highlighting the role of the history to explicitly model the relations between the other factors that affect the script enactment. Research on theoretical models sheds light over how to consider all the aspects in a holistic and integrated manner in regard to the design of CSCBL scripts. Next subsections revise these theoretical models and present the definition of the 4SPPIces factors and their facets.

Approaches towards the design of complex collaborative activities

First, we adopt the ideas behind the constraint-based flexibility framework by Dillenbourg and Tchounikine (2007) and the SPAIRD (Tchounikine, 2008) and SWISH (Dillenbourg & Jermann, 2007). These approaches underline the importance of designing flexible systems in order to be able to support the unexpected events typical in the enactment of CSCL scripts. In all these models, flexibility is defined in terms of intrinsic and extrinsic constraints. The intrinsic constraints arise from the principles on which the script has been based and must be respected in order to achieve a fruitful collaboration. The extrinsic constraints arise from those elements induced by the technology of contextual factors (limitations in the number of students, evaluation elements, etc.). The proposed dissociation of constraints marks the boundaries of flexibility for both teacher and students, and provides the basis for a computational platform of interaction. This platform should be sufficiently flexible to maintain interaction patterns in the light of extrinsic constraints, without violating the intrinsic constraints in each of the phases of the script development process (edition, instantiation, and enactment).

Second, we incorporate the space factor inspired by models of mobile learning such as the one by Sharples et al. (2010) and Spikol and Milrad (2008). These models hint at how to consider the space where the activity occurs as a conditioning factor in the design of CSCBL scripts and its relation with activities and technologies. In this paper, we consider that mobile learning activities, when structured and focused in collaboration, are a particular type of CSCBL scripts. Then, these models of mobile learning remark the importance of the space in relation with the other factors.

And third, the interrelation between the different factors is inspired by the 4 C/ID four-component instructional model to design programs supporting complex skills acquisition by van Merriënboer et al. (2002). This model is an example of how different components of a different nature can be interrelated and integrated to facilitate the achievement of sets of learning goals. The idea behind the 4 C/ID model is that environments for supporting complex learning have to coordinate and integrate activities to facilitate the attainment of sets of learning goals. CSCBL scripts are also complex learning situations that demand the integration of activities occurring at different spatial locations and supported with a variety of technologies. Thus, CSCBL scripts require the interrelation of different components according to a set of learning objectives. The 4 C/ID model sets the basis of how the different identified factors can be related.

All these models incorporate some of the factors characterizing collaborative blended learning activities, such as the importance of the locations where learning activities occur or the flexibility that orchestration systems in blended learning settings demands. However, none of these models combine all these factors into a one unique representation stressing their relation with the activity learning flow or the characteristics of the participants involved in the activity. 4SPPIces disentangles all the factors involved in CSCBL scripts and integrate them making explicit how they are combined.

Factors and facets of 4SPPIces

Figure 1 Shows a schema of the 4SPPIces factors, their facets and their inter-relations

First, the **Space factor (S)** defines the space where the learning activity occurs and its elements (Pérez-Sanagustín et al. 2010). The space can be of two types: virtual and physical. In *virtual spaces* (e. g., a learning management system) the participants manipulate virtual elements that are not necessarily located at the same place (e.g. shared documents, chat

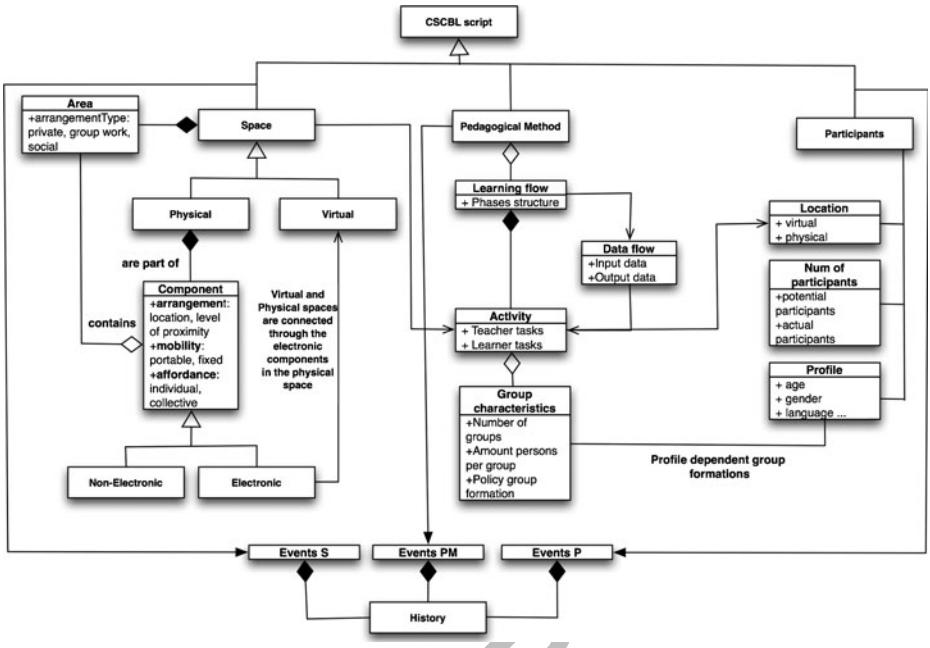

Fig. 1 4SPPIces model. Factors and facets to be considered in the design of CSCBL scripts and of the technological environment for supporting their enactment

rooms…). In *physical spaces*, participants can physically manipulate the elements of the environment. Inspired by ideas coming from research on learning spaces and ubiquitous computing, this factor represents the planned environment where the activity takes place, with the available technology. Researchers in these fields consider the physical space as a contextual factor that can enable or inhibit learning by shaping users' interactions that can activate collaboration (Ciolfi, 2004; Gee, 2005; Oblinger, 2005; Oblinger 2006). The characteristics of the elements composing the space determine the interactions that can occur in that space. For example, whether the elements of the learning environment are portable or not, electronic or not, sharable or not, conditions the way students are distributed over the space and how they move or interact affecting the way in which the learning flow is defined (Pérez-Sanagustín et al. 2010). In this way, a learning space will be characterized by the *Arrangement* of the elements that compose it (location and organization of the elements composing the space), their *Mobility* (whether they are portable or not) and their *Affordance* (describes whether these elements are used individually, collectively or collaboratively). Notice also, that one activity of the learning flow may involve different spaces at the same time in case the students are distributed.

The second is the **Pedagogical Method factor (PM)**. The definition of this factor is prompted by the ideas that arise from the CSCL scripting field (Dillenbourg & Fischer, 2007; Dillenbourg & Hong, 2008; Weinberger et al. 2009). This factor adopts some of the concepts of the scripting practices and proposes: 1) to structure the activities, occurring in sequence or in parallel, in a *Learning flow*, 2) to differentiate the teachers' and learners' tasks through the *Activities*, 3) to define the *Group characteristics* for each activity and 4) to define the inputs and outputs that will be generated from one phase to another, which corresponds to the *Data flow*. The Data flow facet takes into consideration the ideas behind

the concept of integrated scripts. These scripts contemplate a computational integration of the data used and produced across the different learning activities to define an integrated learning experience (Dillenbourg & Jermann 2007). Therefore, the PM is any didactic description of a sequence of activities that define what learners and teachers should perform, the groups' characteristics for producing the interactions to reach the particular learning objectives and the data flow that assures the activities' integration.

Third, the **Participants factor (P)** is dedicated to capture those aspects related to the students participating on the activity. Four facets comprise this factor. The first takes into account the *number of potential and actual number of participants*. This distinction is considered in order to design technological systems able to lead with the flexible requirements during the CSCBL script enactment related to the number of participants (Dillenbourg & Tchounikine, 2007). The second and third facets are related. On the one hand, the students *Profile* facet takes into account those characteristics of the students that can affect the way in which the activity is structured. For example, we can have advanced and non-advanced students and assign one or another activity to each one. On the other hand, it is possible to group the different students according to the elements defined in their profile such as their language. This is modeled in the *Profile-dependent group formation* facet. Finally, the physical location of the students for each activity is also important. Now it is possible to conceive scenarios in which, for example, a group of students from Valencia attends a class in Barcelona through an audiovisual conference system. Students can be *located* in one of the two spaces, Valencia or Barcelona, for the same activity. Since, in such cases, the dynamic of the collaborative activity changes depending on the location of the students, the Participants factor includes the *Location* as one of its facets. Notice that, although the Space factor and the *Location* facet are related, they describe different aspects. While the Space describes all the spaces involved in the activities of the learning flow and their characteristics, the *Location* is related to the Participants and indicates where they are positioned within these spaces along the whole activity. Thus, although one activity may occur at different spaces at the same time, the position of the students in such activity will be determined by their location.

Finally, the fourth factor is the **History (H)**. The H*i*story describes what happened with respect to the facets of the previous three factors whose (unpredictable) variations affect the potentially fruitful activity enactment. This factor is inspired again by the research on CSCL scripts, especially in the above-mentioned studies about the flexibility needs during the scripts' enactment. The literature distinguishes between three different phases when talking about scripting processes: the design phase (where the script is defined), the instantiation phase (how the script is related to the learning situation) and the enactment phase (when the instantiated design is delivered to the participants as an activity to perform) (Hernández-leo et al. 2006; Weinberger et al. 2009). Therefore, in order to design a technological support for the enactment of the CSCBL script, it is essential to consider those facets implied in all these phases. The nature of the History factor has to do more with those issues that, when the activity is enacted, need to be considered for assuring a coherent and integrated learning setting. For example, the role assigned to a student in the first activity can affect the role that it is recommended (from the pedagogical method perspective) for this student to play in the second phase. With this aim, the History is characterized by three facets directly registering the flexibility requirements that have to do with the rest of the factors in the model: S events (those flexibility requirements regarding to the Space factor), PM events (those flexibility requirements regarding the Pedagogical Method) and P events (those flexibility requirements regarding the Participants factor). The idea behind this factor is to make the users of the model reflect about those relations among factors that can affect the enactment of the experience in order to build up systems and mechanisms for dealing with them.

4SPPIces in a real educational design: A case study

Case studies provide valuable information regarding the influence of technology in a particular context and have proved to be very useful for providing answers to 'How' questions (Rowley, 2002). As Zelkowitz & Wallace (1998) state, case studies enable monitoring an authentic situation by extracting information from the data about the different attributes characterizing its development. Thus, case studies help evaluating how technology affects and transforms a context.

We propose an "instrumental" case study as the evaluation method that fit our research scope. Instrumental case studies, beyond learning about the educational situation itself, are instruments for researchers to understand the implications of specific interventions in the context of the particular case (Stake, 1998). The intervention here has to do with the application of 4SPPIces into a real educational context for implementing a CSCBL script and its associated technological environment for supporting its enactment. Thirty four bachelor students of the second course and two teachers participated in the experiment.

This section presents the details of the case study to tackle the research questions. First, the designed CSCBL script and its associated technological environment are described. Second, the methods and analytical strategies employed for addressing the CSCBL script evaluation are presented.

Design and implementation of the CSCBL script

The design of the CSCBL script is achieved as a result of a participatory design process with two practitioners (the main teacher and an assistant). Participatory Design is a field of research and an evolving practice among design professionals that has strong historical roots in the Scandinavian traditions (Gregory, 2003). Researchers in this field explore conditions for user participation in the design and introduction of computer-based systems at work (Kensing & Blomberg, 1998; Schuler & Namioka, 1993). Participatory design methods enable the people destined to use technological solutions to be involved in their design. Participatory design can lead to hybrid experiences that share attributes of both the workers' space (in this case the teachers from the high school) and the software professionals' space (researchers as technicians) (Muller & Kuhn, 1993).

In this study, we adopt participatory design as a method for the design of CSCBL scripts using 4SPPIces. 4SPPIces was the instrument for communicating with the practitioners. Although the use of the model was transparent for the teachers, it was used to define a preliminary illustrative scenario to show the teachers the possibilities that ICT offers for education and to encourage them to reflect about how could they apply these technologies in one of their practices. We followed an adaptation of the scenario-based approach design proposed by Carrol (2000).

Due to availability limitations for the teachers, two meetings were possible and most of the work was done via e-mail and telephone conversations. The 4SPPIces-based scenario was employed during the meetings for: (1) structuring the design process according to the aspects considered in the model, (2) guiding the decisions in defining the narrative of the CSCBL script and the educational materials needed for the activity and (3) identifying the requirements of the technological environment. Therefore, the 4SPPIces-based scenario promoted and facilitated communication among the teachers as a support for discussing how to enhance the Geography course activity so as to reach a CSCBL script adjusted to the teachers' circumstances, interests, needs, and learning objectives.

The next section shows the resulting CSCBL script, including the information about the different phases, how each phase was implemented and the associated materials. The actual materials exchanged with the teachers are listed and described in Tables A.1 and A.2 in the Electronic Supplementary Material.

The CSCBL script narrative, technological environment and materials

The script resulting is named "Discovering Barcelona!" and its narrative describes a learning flow composed of four phases: 1) *Assigning the districts*, in which each student individually answers a questionnaire about the different districts of the city, 2) *Discovering the district*, in which students using handheld devices with GPS explore the district they have been assigned to; 3) *Reflect about your district and learn about other districts*, in which the students are asked to prepare and perform a presentation about the district they have visited, and 4) *Test your colleagues*, in which the students are asked to prepare some questions about the district visited to their colleagues. Only phases 2 and 3 are mandatory.

The **technological environment** designed for supporting the CSCBL script combines four technologies/applications: a Moodle platform (Dougiamas and Taylor 2003), Google Spreadsheet (Google Spreadsheet website), QuesTInSitu Application (Santos et al. 2011) with mobile devices and the Mscape (Stenton 2007) application. Figure 2 shows a schema of the different phases and their supporting technologies. See also section A.II of the Electronic Supplementary Material for more information about the technological environment designed.

- **Moodle Platform**: provides the mechanisms for facilitating teachers and the students an overview of the complete learning flow and the description of tasks for each phase.
- **Google Spreadsheets**: to support the group formation.
- **QuesTInSitu and mobile devices**: a web-based application that enables the generation of questions that can be automatically corrected and to associate them to a geographical coordinate with GoogleMaps (Google Maps website). QuesTInSitu includes a functionality to create routes complemented with a monitoring system. Routes are sequences of geo-located questions created and organized by the user. The routes are visualized in a Google map as a set of markers. The monitoring system provides information about the students' evolution of these routes in real time. When a user answers a question the database of the system is updated and the marker associated to this question changes from green to red. The teachers can visualize the progress of the students along the route on real time by looking at the red and green markers. Clicking on the markers, the teacher can also know who answered the question and the score.

QuesTInSitu allows two types of mechanisms for answering the questions: (1) answering the questions online by accessing the application through a browser (Assessment in *virtual* situ) and (2) using a portable device to answer a question at the same geographical location to which the question is associated (Assessment in *real* situ). Since the exploratory activity requires different groups performing the activity simultaneously in different locations of the city, for this experiment we used the second option. Both the assessment in *real* situ and the monitoring functionalities are used in the *Discovering the District* phase.

- **Mscape:** is a mobile media platform for generating what is called a mediascape. Mediascapes are maps that associate a digital media file with a GPS position that allow triggering multimedia content based on the context, such as physical location. These maps can be installed in GPS mobile devices or PDAs. The GPS device senses the position of the user and throws the media file associated with this geographical

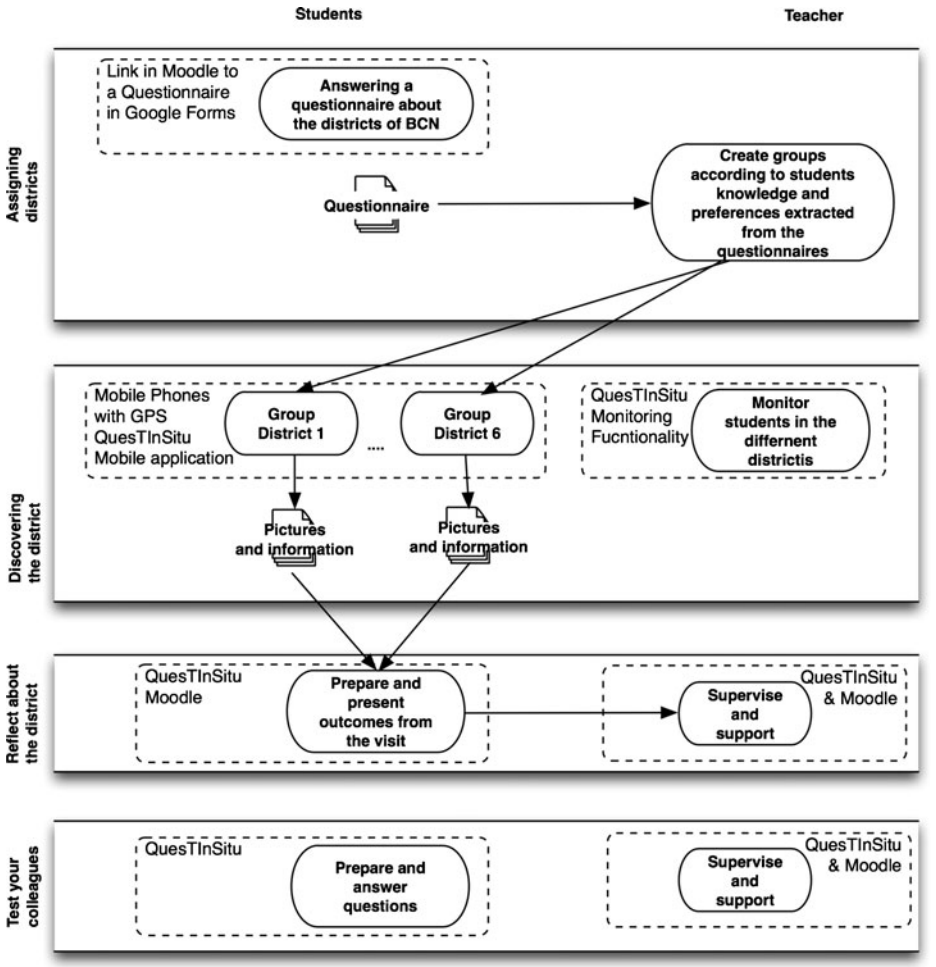

Fig. 2 Schema of the technological environment generated for supporting the students' and teachers' tasks during the enactment of the CSCBL script

coordinate. For the experiment, Mscape was used to complement QuesTInSitu to provide a more intuitive and integrated experience for the students. QuesTInSitu enables relating a question to a geographical coordinate, but does not integrate a module for detecting the actual position of the students in real time. Three mediascapes were created for the experiment. Since some of the districts in Barcelona do not have good GPS coverage and the GPS devices do not work properly in these areas, the Mscapes were created for the whole route only into two districts (Eixample and Les Corts) and in a part of the SantMartí route. For the rest of the districts the students were provided with a map indicating the location of the different questions.

The teachers also indicated that it was necessary to deliver some materials to the students as a complement for the activity:

- a dossier with the description of the different phases.

- a template to fill in during the route according to his/her role in the group.
- a map of the assigned area for the students to help them in following the route and to facilitate having a general overview of the district. For those districts with GPS coverage, the maps did not contain any information about where to place the questions because the GPS served as a guide indicating where to answer the questions (Fig. 3, bottom). In contrast, those groups without GPS coverage had the questions indicated in the map (Fig. 3, top).

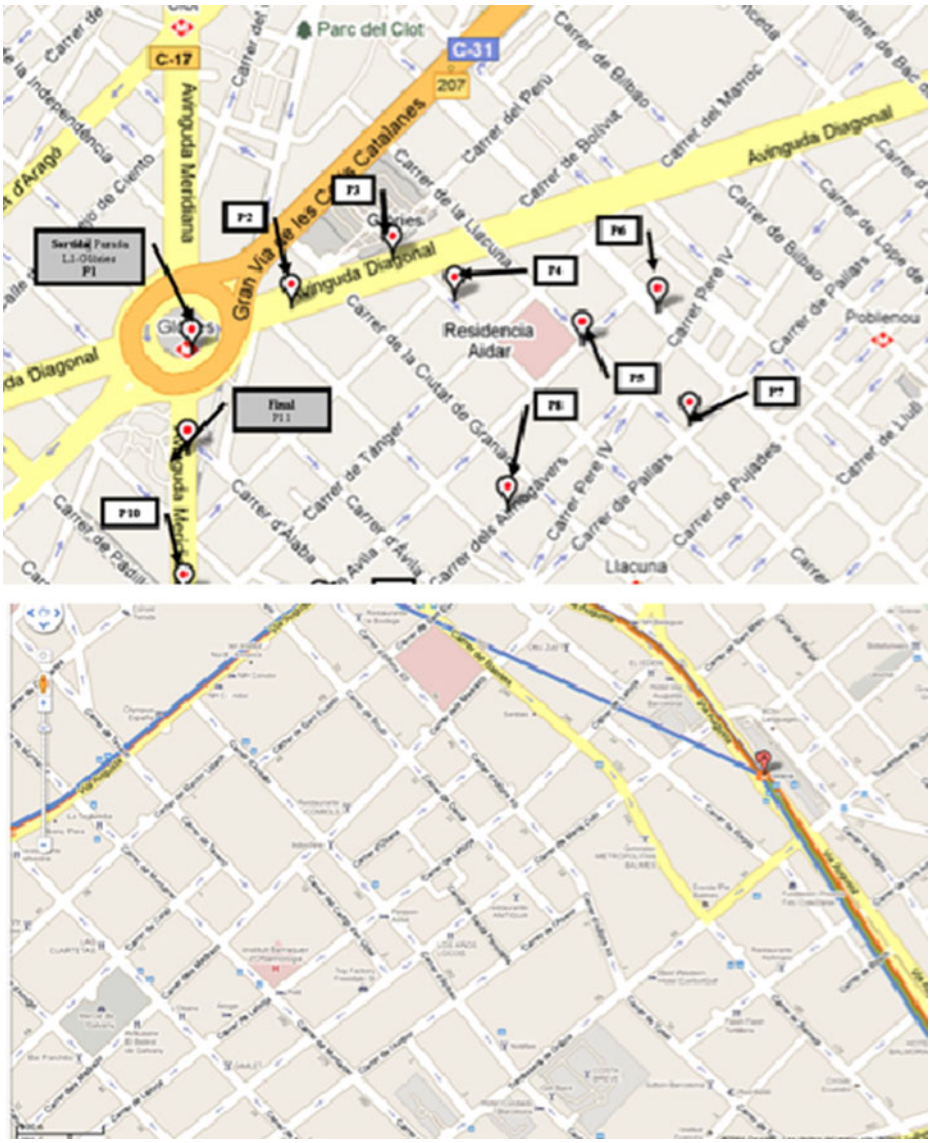

Fig. 3 Maps delivered to the students during the visit. On the top, an example a map delivered to the students assigned to the areas without GPS coverage. On the bottom, an example of a map delivered to the students assigned to areas with GPS coverage

The result of this design process is a CSCBL script that combines four structured and interconnected collaborative activities (Pedagogical method, History) supported by a variety of technologies that enable coordinating groups of students (Participants) at the classroom, at home and across the city (Space). Within this structured activity flow, activities such the exploration with mobile phones, typically of an informal nature, become formal when integrated in the script with traditionally formal activities such as answering an online questionnaire.

Implementation of the phase *Assigning Districts*

The 34 potential students (P, *Number of participants*) were distributed into 6 groups of 5 or 6 people (PM, *Group characteristics*). Each group member was asked to answer individually a questionnaire about the different districts of Barcelona at home using their personal PC (S, *Location*). The objective was to define the students' profile with their initial knowledge about the city and their main preferences with regard to one or other district (P, *Profile*). The information obtained from this questionnaire was used to assign the groups to a particular district associating them to an area that they did not already know, in order to maximize their potential learning, (P, *Profile dependent group formation*) as follows: when most of the group members fail the questions about a district, the group was assigned to this district. The groups in this phase were the groups for the following phase (I, *Events on PM-outcomes from phase to phase- and Events on P-groups in each phase-*).

In this phase, **Google Spreadsheets** were employed for the group formation. The pre-questionnaire for identifying the students' knowledge about the districts and their previous knowledge was created with the Google spreadsheets tool. According to the literature in CSCL, the script should be flexible enough for leading with unexpected events when enacted in a real setting (see section Approaches towards the design of complex collaborative activities). In this phase, the main flexibility issues are captured by the *History* factor: the number of students per group can vary and also the number of students per group answering the first questionnaire about the district. Google Spreadsheets enabled visualizing in a simple Table the answers of the different students and easily change the group organization. With this information the teacher assigned each group to a district: Sarrià (5 students), SantMartí (6), CiutatVella (6), Gràcia (5), Eixample (6) and Les Corts (6).

Implementation of the phase *Discovering the district*

This phase was based on the learning flow Collaborative Learning Flow Pattern (henceforth CLFP) Guiding Questions (PM, *Learning Flow and Activities*) (Hernández et al. 2010). The idea of this pattern is to provide the students with a list of questions that they should be capable of answering as they advance in the task. These questions were expected to help the student in focusing their attention on the important issues of the task. The questions were distributed and geo-located across 6 different districts in Barcelona forming 6 different routes: Sarrià, Gràcia, CiutatVella, SantMartí, Les Corts and l'Eixample (S, *6 mobile phones available=6 districts*). This means that in the same phase there were 6 groups performing the exploratory activity simultaneously in 6 different spatial locations (P, students' *Location*). The students answered the questions along the route when arriving to the specific geo-located point. Each question had an associated feedback that guided the students to the next question and gave them hints about the urban and social characteristics of the area.

Each of the group members was assigned to a role as a means to assure an appropriate task distribution, to foster the individual responsibility, mutual support and positive interdependence. The roles agreed with the teachers were:

- Mobile Phone Manager: in charge of wearing the handheld device, read the questions to the rest of the group members and answer it according to the whole group opinions.
- Guide: in charge of guiding the rest of the group through the streets with a map created for the different districts.
- Photographer: in charge of taking representative pictures justifying all the aspects specified by the teacher and uploading them to a web application specially developed for the experience.
- Question Helper: in charge of taking notes of the ideas and comments related with each of the questions of the route.
- Observer: in charge of annotating the main aspects and comments related with the characteristics of the district specified by the teacher such as the morphology of the streets, the number of parks or the public services available.

In this phase, the students used mobile smart phones Samsung Omnia I and II with QuesTInSitu and MScape.

Implementation of the phase *Reflect about the district*

In this phase the students prepared a presentation about the district they had visited. They could use the notes, observations and pictures taken during the route. Each group had to present their work in the classroom to the rest of the students and deliver it to the teacher two weeks after the exploratory activity. The outcomes from the previous phase were used here as an input for preparing the presentation (PM, *Data flow*).

The students could use any tool to prepare their presentations.

Implementation of the phase *Test your colleagues*

Students could propose questions about their assigned district to their mates. Then, they could individually choose any of these questions and answer them as a self-assessment activity. Unfortunately, this phase, although originally present in the script designed, was cancelled in the last-minute because of time limitations (coincided with the Spanish official period of high school examinations). Therefore, no data about this phase have been considered for the case study evaluation. For this phase it was planned to use the web questions functionality of QuesTInSitu.

In all phases, the **Moodle**[1] **platform was employed to** provide a means to visualize and manage the learning flow, the data flow and the students' groups (Fig. 4). Task assignments were managed for the different groups via the credentials provided to the different users for accessing the Moodle. In this way, it was possible to store the activity of the students as individuals or as a group member.

[1] http://gti-learning.upf.edu/moodle/

Fig. 4 Moodle course developed to provide teachers and students with an overview of the learning flow. This course was used to centralize the access to the rest of the applications used in the experiment to support the activities

Evaluation methodology and analytical strategies

The main goal of this case study is to evaluate whether a CSCBL script that considers the 4SPPIces factors is useful for a particular context. The enactment of the CSCBL script involves an authentic learning situation, which includes many factors such as contextual issues, characteristics of students and educators, the achievement of the educational benefits, and the impact of software tools. We concentrate on two main focuses for analyzing the experiment:

- **Focus I relates to the innovation and added value of the CSCBL script**; i.e., whether the CSCBL script solves the limitations of the previous practices covering the main learning objectives highlighted by the teacher.
- **Focus II relates to the appropriateness and suitability of the collaborative technological environment associated to the CSCBL script for supporting the students' and teachers' tasks**. The strengths and limitations experimented by both teachers and students during the enactment are also considered in this point for further improvements.

All the data were aggregated and analytically compared using a mixed evaluation method (Martínez-Monés 2003; Frechtling & Sharp, 1997). This technique is especially interesting for experiments that put into practice new technological usages into an authentic learning situation (Johnson et al. 2007; Maxwell & Loomis, 2003). Rather than confirming or rejecting a research hypothesis, the aim of this evaluation methodology is to identify tendencies in the aforementioned issues in this particular learning context. To capture information from the context we mix quantitative data coming from closed questions and event log files generated automatically by the mobile phones, with qualitative data such as open-ended questions and first-hand observations. The quantitative data are useful for showing trends, and the qualitative data provide an in-depth understanding of the CSCBL script enactment (Adams et al. 2008).

Mixed methods are applied on three phases: (1) Definition of a scheme of categories, (2) data collection and (3) Analysis and interpretation.

(1) Definition of a scheme of categories

The definition of categories can be done empirically (according to past experiments) or theoretically (according to the specific objectives of the experiment). We followed the second approach. New categories can emerge throughout the study, which means that this initial definition can vary (Martínez-Monés et al. 2003).

To guide the definition of this scheme of categories, for each of the focus of analysis we define different issues to be analyzed with their associated information questions. The issues and associated information questions related with the **first evaluation focus** (I) are:

- **Issue I.1**: *Added value of the CSCBL script in terms of learning benefits related with the course content, collaborative learning and motivational aspects*. The information questions related to this issue are: (1) Which is the added value of the CSCBL script in terms of learning benefits related with the course content? (2) Does the mixture of activities integrated into the same learning setting support students' reflections about the explored environment and the concepts worked in class? (3) Does the CSCBL script and its grouping and task distribution policies support the acquisition and practice of communicative and collaborative skills and (4) Does the script foster the students' motivation?
- **Issue I. 2:** *Innovative aspects with respect to previous editions*. One information question is related to this issue: (1) What are the aspects that make the activity innovative with respect to previous editions?

The issues and associated information questions related with the **second evaluation focus** (II) are:

- **Issue II.1**: *Successful aspects of the technology designed for supporting the teachers' and students tasks'*. The information questions related to this issue are: (1) Is the combination of the technologies appropriate for supporting teachers' orchestration tasks? and (2) Is the combination of technologies appropriate for supporting students' tasks?
- **Issue II.2:** *Limitations and suggested improvements of the technology designed for supporting the teachers' and students' tasks*. The information question related to this issue is: (3) What are the limitations and suggested improvements of the technological collaborative environment for supporting teachers' and students' tasks?

(2) Data collection

The data collection consists in collecting qualitative and quantitative data using different techniques such as questionnaires, log files, observations, video recordings… Figure 5 shows the data extracted along the experiment and the technique employed.

The Students Outcomes questionnaire with open and closed questions used to extract information about the knowledge of the students about the city before the experiment. The [Q-st-route], [Q-t-route], [Q-st-final] and [Q-t-final] included closed and open questions about the students' and teachers' perceptions of phase 2 and of the whole activity, respectively. Finally, the [Videos-route] and [Videos-presentations] obtained in phases 2 and 3 gave qualitative information about the behaviour of the students and teachers along the whole activity. The marks and contents of the students' [Presentations] were used as a quantitative and qualitative data to have an overview of the knowledge acquired about the city. Finally, the [Observations] taken by different researchers in phase 2 were used as qualitative information related to the technology usage.

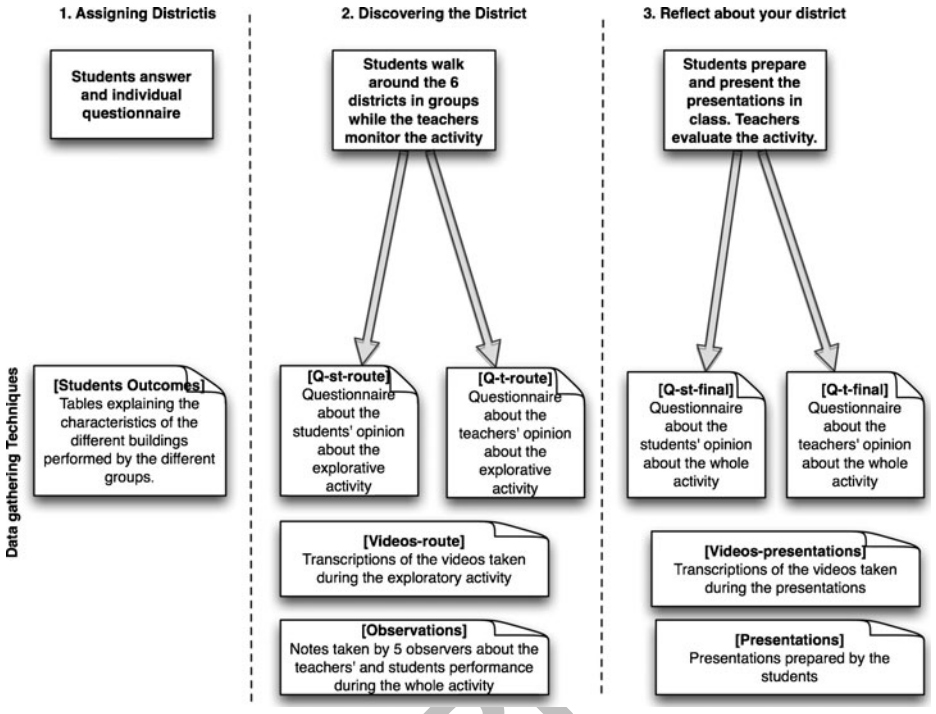

Fig. 5 Data gathered extracted along the experiment

(3) Analysis and interpretation

According to the mixed evaluation method applied, the emphasis is more on the qualitative than on the quantitative analysis. For interpreting all these data, we used a method called "triangulation" (Guba, 1981; Guba and Lincoln, 1994). This method consists in reinforcing each of the interpretations extracted through a comparative analysis of evidence provided from different sources. That is, to analyse each conclusion from a different perspective in order to have several confirmations supported by both qualitative and quantitative data.

The final marks of the students' projects and the results of the closed questions in the questionnaires constitute the quantitative data of the experiment and were analyzed using a Spreadsheet. To structure and triangulate the qualitative data we used Nud*Ist (Gahan & Hannibal, 1998). This application enables relating the data from different sources to the different categories defined in the first phase. The result is a project in which the data coming from the different sources is categorized according to the research objectives.

Finally, both the quantitative and qualitative data are organized in Tables according to the different information questions. This organization facilitates deriving a list of partial results for the different issues under study supported by different data sources (Tables A.6 and A.7 of the Electronic Supplementary Material). These partial results are related and organized into the list of findings in Table 1. The next section presents and discusses this Table. The final process of extracting conclusions was discussed and analysed by the two researchers.

Both the original data employed for the evaluation as well as the Nud*Ist project created for the experiment with the list of categories defined can be found in the Electronic Supplementary Material.

Results and discussion

In order to facilitate the readability of the findings, we have organized them according with the two foci of the study introduced in the previous section. The results are presented as follows:

- **Bold text** is used for emphasizing the main findings related with the issues under analysis in each focus.
- "Text between quotations" is used to indicate the sentences and comments of the students and/or teachers.

Focus I: Innovation and added value of the CSCBL script

The findings of the first focus of study as well as the partial results that support them are summarized in Table A.6 of the Electronic Supplementary Material.

The first finding (I.1 in Table 1) indicates that the **CSCBL script copes successfully with the limitations detected by the teachers in previous editions of the experience and entails new learning benefits**.

Different partial results supported by qualitative and quantitative data provided evidence for this finding. First, observations and comments of the teachers and students after the exploratory experience show that the experience promotes students' autonomy and active learning [Q-st-route, Q-t-route, Observations]. Second, students' and teachers' comments at the end of the experience suggest that the usage of mobile phones and GPS is perceived as an opportunity to practice and enhance technological and orientations skills not commonly worked in the traditional activities [Q-st-route, Q-t-route]. Third, teachers and students agree

Table 1 Summary of findings of the empirical study

Summary of findings
Focus I. Innovation and added value of the CSCBL script
I.1. The CSCBL script copes successfully with the limitations detected by the teachers in previous editions: students learn about sociological and urbanism characteristics of 6 different districts of Barcelona working in groups and using technology.
I.2. The CSCBL script promotes the collaboration and cooperation between students and developing teamwork skills.
I.3. The CSCBL script is a motivating experience that promotes the active participation of the students and is innovative compared with similar experiences because of the use of technology.
I.4. Students and teachers feel comfortable with the pre-test district assignments policy and role-distribution as a successful mechanism to structure collaboration.
I.5. Combining exploratory activities with the presentation work into an integrated learning setting promotes students' reflection about concepts acquired in class and in other courses. Teachers also consider this integration necessary to provide a complete evaluation of the activity.
Focus II. Appropriateness and suitability of the collaborative technological environment associated to the CSCBL script for supporting the students' and teachers' tasks
II.1. The mobile and GPS devices combined with the monitoring functionalities included in QuesTInSitu and the Moodle platform provide teachers with a support to follow students' activity.
II.2. Mobile devices complemented with a map as well as the questions are a successful mechanism to organize, structure, support and guide the actions during the exploratory phase.
II.3. The technology employed in the CSCBL script is usable appropriate for the experience.

with the idea that using mobile phones and automatic assessment functionalities help focus attention on the environment, and remembering and reflecting about the contents. And fourth, teachers highlight that the activity, compared with previous experiences, enables learning about different areas of the city with new important benefits. One teacher commented on the added value of the experience: "Using these tools – ICT - in an urban environment and having the possibility of learning about more districts of the city" [Observations]. This evidence was also supported by the results of a closed question in which students were asked whether they learn more using the mobile in situ than in filling a dossier or doing an exam. 28/34 (82%) chose the mobiles, 4/34 (12%) the dossier and (2/34, 6%) did not answer the question [Q-st-route]. Also, 33/34 (97%) of the students indicated after the whole experience that the activity helped them to learn new concepts about the districts. 23/34 students (68%) valued their feeling of learning with four points over five on a Likert scale (from 1 to 5) [Q-st-final].

These partial results indicate that considering the S and PM factors promotes innovative usages of technologies such as GPS and mobile phones that entail new learning benefits for the students.

The **second finding** (I.2 in Table 1) shows that **structured group activities, the role-distribution during the exploratory phase as well as the pre-test district assignment policy promoted collaboration and cooperation among students by enhancing teamwork skills.**

Different partial results support this finding. First, the students' comments and observations by experts suggest that structuring the group activities with an explicit role-distribution helped on the task distribution, which promoted an active participation of the whole group, made the activity more dynamic and promoted discussions fostering the students' communicative skills and reinforcing cooperation [Q-st-route, Q-st-final, Q-t-route, Q-t-final, Videos-route]. Some students explicitly appreciated the role distribution as a mechanism to make all group members feel that all are participating and cooperating and are conscious of the positive interdependence among group members that this generates [Q-st-route, Q-st-final]. Also, a quantitative result reinforces the qualitatative evidences showing that 34/34 (100%) of the students answered in a closed question on the final questionnaire that it was helpful working in groups. Second, students' answers support a partial result that indicates that organizing the exploratory phase through a sequence of questions and with feedback guide the students' along the activity at the same time that promoted debates that made students reflect and look for agreement enhancing cooperation [Q-st-final]. The guidance of the feedback is corroborated by yes/no question of the questionnaire about the route. 33/34 (97%) of the students indicated that the feedback helped them to know how to continue in the activity and their progress on it. Third, working directly in contact with the environment enhances student's interactions with people in the city helping them to practice their communicative and social skills in situations they are not used to [Observations]. Finally, as a fourth partial result, the transcriptions of the video presentations indicate that all group members in all the work teams contributed and participated in the final presentation.

This finding shows that considering the facets of the PM and P factors enable conceiving complex collaborative learning tasks that promoted students' interactions in collaborative skills.

The **third finding** (I.3 in Table 1) indicates that the CSCBL **script is a motivational and innovative activity for students and teachers compared with previous experiences**.

First, students used positive adjectives such as different, interactive, fun, dynamic and interesting for describing the activity. Student's comments about the exploratory activity support this partial result: "I liked the activity because it is an activity very different from the rest (of the activities out of the classroom)" [Q-st-route] or "The experience changed the way in which we are

used to do school trips" [Q-st-route]. When referring to the whole experience they say: "It (the experience) has been more interesting than the 'typical museum visit' and it has been more fun" [Q-st-final]. Also quantitative data reinforced this result. Students indicated high ratings for the Discovering Barcelona phase: 24/34 (71%) of the students qualified it with 4 over 5 and 10/34 (29%) with 5 over 5. 34/34 (100%) of the students and the two teachers would repeat the activity on another course for learning about another district [Q-st-route, Q-t-route]. Second, students enjoyed working in groups and highlighted this as one of the most positive and innovative aspects of the activity. For example, when a student was asked if he preferred this activity compared with similar experiences he comments: "Yes. This activity is better and more fun compared to other activities (such as going to a museum). Moreover, this activity allows us to work in groups in a very fun way" [Q-st-final]. Finally, the third partial result indicated that students perceived the CSCBL script as an innovative experience compared with previous similar ones because of the use of technology and, in particular, mobile phones. Both, students and teachers, saw the use of ICT as one of the aspects that make the experience innovative and different from others. Students saw that working with mobile and GPS is an original and motivating experience and stressed the fact that it is not common to use technological devices in educational activities [Q-st-final]. This is also reinforced by a quantitative result. In a question asking about the experience as a whole, 31/31 students (3 students did not attended the class that day) said that they preferred this activity compared with similar ones [Q-st-final].

This finding indicated that considering the 4SPPIces factors has enabled us to conceive an activity that proposes innovative usages of technologies with educational intentions. The interrelation between the different factors enables identifying which technological support is better to use for the educational purposes.

The fourth **finding** (I.4 in Table 1) indicates that the **integration of the exploratory activity with the presentation task into the same learning setting promotes students' reflection about the contents studied in class and in other courses and is seen by the teachers as a condition necessary to provide a complete evaluation of the activity**.

Different partial results supported this finding. First, observations by experts show how students, during the route, made references to concepts and topics worked in class [Observations]. Second, observations taken during the students' presentations and comments by the teachers show the importance of integrating exploratory with more reflective activities into the same learning setting. Third, the observations taken from the videos of the presentations and their contents showed that the students used multiple sources of information to complement their explorative experience [Presentations, Videos-presentation]. And fourth, teachers stressed the idea that the visit and the presentation activities were complementary [Observations] and a good mechanism to "apply in a concrete way the contents explained in class" [Q-t-route]. Therefore, all these partial results showed how both teachers and students perceived the different phases of the activities as a unique learning setting.

Finally, this finding showed evidence for the importance of the Data flow facet of the PM factor. This facet and their relation with the other factors facets in the model (all captured by the History factor) emphasizes the importance of creating a technological environment in which the different activities are interrelated.

Focus II: Suitability of the technological environment for supporting the CSCBL script

The findings of the second focus of study as well as the partial results that support them are also summarized in Table A.7 of the Electronic Supplementary Material.

The **first finding** (II.1 in Table 1) shows that **the mobile and GPS devices combined with the monitoring functionalities included in QuesTInSitu and complemented with a**

Moodle platform are a good support for teachers to control the groups' progress during the whole experience, especially during the Discovering Barcelona phase. Different partial results supported this finding.

First, the technology designed reduces the organizational teachers' efforts during the exploratory phase. The exploratory activity is the activity that entails the most complexity in terms of orchestration. However, the observations and comments by the teacher during this particular phase indicate that they could easily and successfully follow what the students were doing on runtime while discussing the answers given by the different groups [Observations]. Second, teachers valued very positively the Monitoring functionality. On the one hand, they selected this functionality as the best one of the system and noted its intuitiveness with the highest mark on a Likert scale from 1 to 5 [Q-t-route]. And third, teachers described the whole technological environment (applications, servers, webs…) in relation with the functionalities provided and the organizational and management benefits that they carry as very well designed and "practical, functional, organized, clear, easy and comprehensive" [Q-t-route].

This finding indicated that the system successfully hides the complexity of the orchestration tasks required. This fact also indicates that, considering the History factor helps in conceiving an orchestration system capable of managing all the important aspects in the rest of the factors and that influence the activity enactment.

The **second finding** (II.2 in Table 1) shows that **the mobile devices completed with a map as well as the questions feedback are a successful mechanism to organize, structure, support and guide the student's actions during the exploratory tasks**.

First, students and teachers highlighted that mobile devices and the automatic assessment and feedback mechanisms were easy to use, useful and a structured and a clear way to guide the activity. The notes by the experts, which indicate that all groups used the feedback messages from the mobile to know where to go in the next activity, support this partial result [Observations, Q-t-final, Q-st-final]. Moreover, 33/34 (97%) students indicated that the feedback helped them to know how to continue in the activity and their progress on it. Second, the use of the GPS and maps complement the guidance provided by the feedback. First, the comments of the 10 students that performed the activity with GPS (groups Eixample and Les Corts) indicate that they felt well guided during the route. Furthermore, when the students in these groups were asked whether they could have performed the activity without the map, six (out of 10 because four did not answer the question) answered affirmatively. On the contrary, the students that did the activity without the GPS (groups Gràcia, Sarria and CiutatVella), although they think that the GPS was not necessary to perform the activity, their comments indicated that they had difficulties finding some locations on the route and would find it useful to use the GPS. For example, one students says: "I think that the GPS would have been useful because sometimes, when answering the questions and listening to the clues for the next question we were confused because we were not correctly located" [Q-st-final_NoGPS]. Finally, those students that used the GPS during half of the route (group Sant Martí), when they were asked to compare the two situations they remarked that they preferred using the GPS because it is faster, easier and practical [Q-st-final_GPS]. Therefore, this comparison among groups indicated that both the GPS and the map complemented the feedback of the questions to guide the students along the route.

This finding shows the importance of considering the 4SPPIces factors together. The relationships between the PM, the S and the P captured by the H indicates that to structure the activity only with technology is not enough and that other complementary materials are needed.

Finally, the **third finding** (3 in Table 1) **shows that the technology employed was usable and appropriate for the experience for both students and teachers**.

First, students preferred using mobile phones for the exploratory activity more than other traditional techniques such as filling a dossier or doing an exam. Most of the students commented that mobile phones allowed them to be directly in contact with the environment, which made it easier to answer the questions and to pay attention to the details [Q-st-route]. Moreover, when they were asked to choose about using a mobile phone, filling in a dossier or doing an exam in class 32/34 (94%) answered that they preferred the mobile. Only two students indicated that they preferred a dossier. Second, the students successfully adopted the technology developed specially for the exploratory experience (the QuesTInSitu application). The observations by the experts indicated that students easily managed the QuesTInSitu application [Observations]. Also a quantitative result corroborated this partial result: 33/34 students (one student forgot to answer this question) answered that this application was easy-to-use. Finally, the third partial result indicated that some problems related with the GPS applications of the mobile phones as well as some functionalities of the QuesTInSitu application should be considered for future editions of the activity. On the one hand, the observations taken by the experts during the exploratory phase and the comments from the students evidence that the GPS failed in particular points along the route with lower coverage [Observations, Q-st-route]. On the other hand, teachers suggested improving the Monitoring functionality of the QuesTInSitu application adding an audiovisual module to see the students' action on runtime [Q-t-route].

All in all, this last finding shows that analyzing and understanding the educational necessities structuring the activity according to the 4SPPIces factors is essential to indentify the requirements of a technological environment for supporting collaborative learning scripting practices combining spatial locations successfully.

Conclusions and future work

This work is focused on presenting an illustrative case study in which a 4SPPIces-based collaborative learning script blending spaces has been enacted in a real situation. The actual context was an authentic fieldwork activity framed in a geography course of a secondary school. Considering the 4SPPIces factors was useful to design a new script overcoming the limitations of previous editions of the activity in a way that the following aspects highlighted by the teachers were addressed: 1) including the visit of more than one unique district of Barcelona city, 2) introducing a collaborative component in the activity and 3) introducing a technological resources as a support for the activity.

Two aspects (or focuses of study) of the CSCBL script enactment have been analysed in this case study: (1) whether the script is innovative enough to solve the limitations of previous practices maintaining the learning objectives and (2) whether the technological system developed is appropriate for supporting the students' and teachers' tasks defined in the script.

The results of this analysis, fruit of an extensive work of data analysis combining quantitative and qualitative sources, show that the CSCBL script designed copes with the three requirements imposed by the teachers. These results enable extracting concluding remarks with regard to the effects of considering the 4SPPIces factors in the design of the script.

First, to consider the *Space* factor has proved to be a good mechanism for extending the previous editions of the activity involving the visit to new areas of the city. Taking into account the spatial locations where the activity occurs has had an impact on the selection of the technological support to be used, mobile devices in this case. Moreover, considering the

Space factor in relation to the number of *Participants* has led to structuring the *Pedagogical Method* around the visit and comparison of six districts in the city. Students directly explored the urbanism and geo-sociological characteristics of one district and learned about other districts from the presentations of their colleagues.

Second, the structure of the CSCBL script and the group management based on a role-distribution inspired by the relation between the *Pedagogical Method* and the *Participants* factors introduced a collaborative component to the activity. The combination of an explorative-type structured activity with a final presentation in class promoted the active participation of all group members making them discuss, argue and think critically by enhancing collaborative and communicative skills and promoting cooperation. Also, this combination and interrelation of more formal and informal types of activities inspired by the *History* factor helps teachers having a complete overview of the concepts acquired during the whole activity.

And third, the interrelation and dependencies between the different factors captured by the *History* factor has lead us to propose an innovative combination of technologies that has been easily adopted by both teachers and students. For the students, technology made the experience more dynamic, original and fun, which had a direct impact on their motivation and, therefore, on their knowledge acquisition. At the same time, findings suggest that using technological support for the activities also entailed other learning benefits for the students, such as practicing their technological and orientation skills. For the teachers, the combination of technologies with other materials such as (maps, guides…) supported them in organizing and structuring the whole activity. Even those activities that required a complex management in real time were carried out successfully. Finally, implementing a technological environment based on the Learning flow facet of the PM factor helped to generate teachers and students the perception of an activity not composed by disconnected phases and activities but as a complete and integrated set of activities.

In conclusion, and based on the findings of the case study, we can state that 4SPPIces has been a useful framework to design a meaningful CSCBL script involving the teachers that successfully extends an actual geography activity. The encouraging results of this CSCBL script evidence the benefits and positive effects of considering the 4SPPIces factors for transforming an actual activity into an innovative collaborative learning activity in the blend, keeping the balance between technology and education.

The 4SPPIces factors have also been considered in other cases in different contexts. In particular, two other CSCBL scripts proposed to support first year engineering students in discovering the University Campus have been generated according to the 4SPPIces factors. One of these scripts has been already carried out and evaluated (Pérez-Sanagustín et al. 2011) while the other, based on a preliminary proof-of concept (de-la-Fuente-Valentín et al. 2010), is still under analysis. We are also comparing the results of these case studies towards a cross-case analysis, shaped as a multicase study in order to achieve contrasted evidences about the usefulness of the 4SPPIces factors. Finally, with the aim of guiding the design of CSCBL scripts and facilitate the computer-supported collaboration between practitioners, we have developed a web-based application based on 4SPPIces that we expect to test with real users.

Acknowledgements This work has been partially funded by the Spanish Ministry of Science and Innovation in the Learn3 project (TIN2008-05163/TSI). The authors would also especially like to thank Pilar Sanagustín Viu, Francesc Santolaria, Tònia Boqué (from the IES Duc the Montblanc) and members of the GTI research group for their support and ideas.

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APPENDIX

"The 4SPPIces factors in a collaborative learning script blending spaces: a case study"

The information of this document is complemented with the actual data obtained from the experiment. This data can be accessed at: http://193.145.50.210:8080/DUCdata/ijCSCL-data/DiscoveringBCN.html

A.I. PARTICIPATORY DESIGN PROCESS DATA SOURCES

This section contains all the data gathered during the participatory design of the CSCBL script carried out with two practitioners of the High School Duc de Montblanc.

Table A1. Shows all the data employed during the participatory design process. Table A.2 organizes chronologically a summary of the meetings carried out and the e-mails exchanged along the participatory design process, a description of the information gathered from the mails and meetings and the outcomes obtained related with the factors and facets of 4SPPIces that inspired the different phases of the CSCBL script.

These tables are complemented with the actual materials exchanged with the teachers, which can be accessed at: http://193.145.50.210:8080/DUCdata/ijCSCL-data/DiscoveringBCN.html.

Table A.1 Data sources used during the participatory design process of the case study.

Data source	Type of data	Labels
2 meetings with the teachers	Transcriptions of the 2 meetings (04/02/2010 and 19/04/2010) with the two teachers participating in the design process.	[Meetings]
e-mails exchanged with the teachers during the design process	Text of the e-mails exchanged with the teachers from the beginning of the process until the final design of the CSCBL scenario (16 mails exchanged)	[e-mails]
Teachers and researchers documentation	Teachers' and researchers' documents produced and exchanged during the CSCBL scenario design process	[Documentation]

Table A.2 Summary of the meetings and e-mail exchanged during the participatory design process with practitioners and their relation with 4SPPIces for the definition of the CSCBL script.

Labels data source	Description	Information & outcomes of the design process	Relation with 4SPPIces factors
[e-mails] Concreting a first appointment (5 e-mails): 13/01/2010-R2T 18/01/2010-T2R 10/01/2010a-R2T 10/01/2010b-T2R 20/01/2010-R2T	Mails exchanged for proposing collaboration with the teachers and making an appointment for the first meeting to discuss about possible experiences (R2T: researchers to teachers; T2R: teachers to researchers)	Definition of the subject of interest: History and Geography Date for the first appointment with the teachers: 04/02/2010	*Not Applicable (NA)*
[Meetings] Meeting 1 - 04/02/2010	Description of teachers' previous experiences "visit Barcelona". Description of the limitations, the main aspects to be achieved with the new experience and a first proposal of the districts to visit. Discussion about the best dates for the experience enactment	- Educational requirements: (ER 1) to have the possibility of visiting more neighbourhoods on the same trip to make comparisons, (ER 2) to perform the activity in small groups, for promoting the students' competences of working in groups and critical thinking (ER 3) to employ Information and Communication Technologies (ICT) in an appropriate manner without distracting the students - First approaches of the scenario narrative with the list of districts to visit (8) - Dates for the experience: April 30 (after the final exams)	- S: 6 districts - PM: Group Characteristics: 5 to 6 people

[e-mails], [Documentation] Learning Flow definition (5 e-mails): 14/02/2010a-T2R,	Document detailing the objectives, motivation and contents of the experience (*2010Feb14 – Objectives – Teachers.doc*)	- Motivation of the experience, the contents, the sequence of activities (learning flow), objectives and topics to be treated during the experience with examples of questions of the students' activities and learning objectives (*2010Feb14 – Objectives – Teachers.doc*) - Description of the activity, work plan and learning flow definition (*2010 Feb 24 Activity proposal – Researchers.doc*) -Routes proposed by the teachers *(2010Feb24 Routes Proposal – Teachers.doc)*	- PM: Learning flow of 4 phases; Activities defined for each phase; Data flow: outcomes from each activity; Group characteristics (5 to 6 people); Potential number of participants (34) - P: Profile (name, district pre-knowledge, group preferences); Profile-dependent-group formation (by preferences and district pre-knowledge); Location (Home, City, Home & Classroom, Home) -S: Elements (6 mobiles = 6 Districts); Arrangement (Home, Students' & Teacher locations, Classroom, Home); Affordance (Individual and collective); Mobility (Fixed or portable) -I: PM: outcomes from phases; P: students' preferences and locations; S: students activity log files
14/02/2010b-R2T	Feedback R2T to mail 14/02/2010a-T2R		
24/02/2010a-R2T	Activity proposal with the work plan and learning flow definition (*2010 Feb 24 Activity proposal – Researchers.doc*)		
24/02/2010b-T2R	Feedback T2R to mail 24/02/2010a-R2T, routes proposal and question regarding the type of information that would be facilitated to the students via mobile phones *(2010Feb24 Routes Proposal – Teachers.doc)*		
24/02/2010c-R2T	Feedback R2T to mail 24/02/2010b-T2R		
[e-mails], [Documentation] Activity contents definition (5 e-mails): 23/03/2010-R2T	Example of questions for one of the routes proposed by the teachers *(2010March23 Questions - Resesarchers)*	- Sample route questions *(2010March23 Questions - Resesarchers)* - Aspects that should be addressed with the questions during the activity *(2010March29 Guide Experience – Teachers.doc)*	- PM: Activity contents and materials
24/03/2010a-T2R	Feedback T2R to mail 23/03/2010-R2T		
24/03/2010b-R2T	Feedback R2T to mail 24/03/2010a-T2R		
29/03/2010-T2R	Teachers agree with the sample of questions proposed and provide a guide with the aspects that should be addressed with the questions in the mobile phones		
20/04/2010-T2R	Names and e-mails of the students	- List of students participating in the experience	- P: Expected number of participants (34)
[Meetings] Meeting 2 – 19/04/2010	Meeting for showing the technological environment and revision of the district assignments proposed, the materials prepared	- Teachers suggest including the main points that the students should consider for preparing the presentations	- PM: Activity contents and materials
[e-mails] 03/05/2010-T2R	Mail T2R expressing the satisfaction regarding the experience and the good outcomes	NA	NA

A. II. REQUIREMENTS OF THE TECHNOLOGICAL ENVIRONMENT

Each of the phases of the CSCBL script is supported by a particular technology selected according to the technological requirements (TR) identified from the mapping of the script narrative with the 4SPPIces factors (the details of this analysis are listed in Table AII.3 in this document).

- TR1. To provide the mechanisms for facilitating the teachers and the students with an overview of the complete learning flow and the description of tasks for each phase.

- TR2. To provide teachers with the tooling to monitor the students' position in real time.

- TR3. To provide the facilities for grouping the students according to their previous knowledge about the city and distribute the activities accordingly.

- TR4. To store the data flow connecting the different activities.

- TR5. To save the information about students' profile evolution (depending on the tasks they perform).

Table A.3 shows the mapping of the requirements defined by the teachers and the 4SPPIces factors facets.

Table A. 3 Technological requirements extracted from the mapping of the 4SPPIces factors with the CSCBL script**. P1, P2, P3** and **P4** stands for each of the four phases. Letter **S** stands for those issues regarding the students and **T** for those related with the teacher. In Italics we indicate those aspects that affect the script on real time.

Facets	**Description of the factors**					**Requirements**
Pedagogical Method						
Learning flow	**P1. Assigning Districts**	**P2. Discovering the district**		**P3. Reflect about your district**	**P4. Test your colleagues**	1. To organize the sequence of phases
Activity/ies	**S:** Pre-web-questionnaire about Barcelona **T:** Check questionnaire answers	**S: (1)**Visiting thedistrict, answering the questionnaires and taking notes and pictures (Mandatory) **(2)** Uploading the pictures to QuestInSitu (Mandatory) **T:**Monitoring the visit		**S:(1)**Preparing a presentation (Mandatory). **(2)**Performing the presentation (Mandatory) **T:**Downloading and evaluating presentations	**S: (1)**Adding questions in QuesTInSitu (Optional). **(2)**Answering proposed questions (Optional) **T:** Checking students contributions	2. To organize students groups, roles assignments and activity distribution
Group Charact.	Individual	**6 Groups** of 5 to 6 people		Equal than in phase 2	Individual	3. To distribute the activities according to the groups.
Data flow	Outcomes from Pre-questionnaire [Quest1-PreRoute.doc]	- Students' deliverables according to their roles - Questions marks - Pictures		Presentations delivered	Questions generated	4. To store the data generated from phase to phase
Participants						
Number participants	Potential participants: 34 *Actual participants: 19* *It affects the group distribution.	Potential students: 34 *Actual students: 34* * It does not affect the activity enactment		Potential students: 34 *Actual participants: 34* * It does not affect the activity enactment	Potential students: 34 *Actual participants: ?* *It does not affect the activity enactment	5. To provide the mechanisms for flexibly managing last-minute changes in groups.
Profile	- Students Name & Group - District Pre-knowledge - Group preferences - Teachers' suggestions	*The profile of the students is updated depending on the role assigned in this phase*		-	-	6. To save the information about the students' profile
Profile-dependent group formation	Students grouped by their preferences and district pre-knowledge	-		-	-	7. To group students according to their preferences and assign them to a district
Location	Students' Home	Assigned district		Home and Classroom	Students' Home	8. To provide mechanisms for monitoring students at each phase
Space						
Elements	PC or Device with Internet access	Portable device with Internet access	Device with Internet access	Projector & PC - Internet access	PC or Device with Internet access	9. To understand which of the devices available best fits with the needs of each phase.
Arrangement	Students' home	Students' location (distributed into 6 districts)	Teachers' location	Classroom	Students' home	10. To support the arrangement in each phase.
Affordance	Individual	Collective	Collective/ Individual	Collective	Individual	11. To support the affordance associated to each phase
Mobility	Fixed or Portable	Portable	Fixed/ Portable	Fixed or Portable	Fixed or Portable	12. To support the portability requirements associated to each phase
hIstory						
Events PM	Missing pre-questionnairedata	-		-	-	13. *Preferences of students that do not answer the pre-questionnaire are not considered*
Events P	Save students' preferences to define groups	Register the groups' locations during the visit		-	-	14. To be aware of the students' location on runtime
Events S	-	Logs with students' activity in QuesTInSitu (questions marks)		Technological limitations and possible problems	-	15. To provide QuesTInsitu with log files showing the students activity

Table A. 4 Brief description of the different phases of the CSCBL script and the technology employed for supporting their enactment.

	Brief Description of the phase	**Technologies and Materials employed for the enactment**
P1. Assigning Districts	Students answer individually a pre-questionnaire about Barcelona districts. According to the responses, the teacher assigns the different groups to a district.	- Moodle platform for a complete overview of all the phases in the learning flow. - Google Forms for the pre-questionnaire and organization of the students in groups.
P2. Discovering the district	Groups of students perform a visit of its assigned district guided by a set of questions that they answer through a QuesTInSitu application on their mobile phones. Each of the group members plays a different role in the activity. Teachers monitor the activity through a QuesTInSitu functionality.	- QuesTInSitu applications for students and teachers. - Paper-templates for the roles and tasks distribution. - Cameras for taking pictures during the visit.
P3. Reflect about your district and learn about the other districts	Students prepare a presentation about their district using the information from the visit and the main aspects worked in class.The presentation is delivered to the teacher via Moodle and presented in class to the rest of the class.	- QuestInSitu to extract the information about the route. - Moodle for delivering the presentations - Projector as a media display device for the presentations.
P4. Test your colleagues	Students can create their own questions about their districts and answer the questions created by their colleagues.	- QuestInSitu to create and answer the questions online.

A. III. EVALUATION

This section contains all the data gathered during the enactment of the CSCBL script carried out with two practitioners and 34 students of the High School Duc de Montblanc.

Table A.5 explain the data sources used for the evaluation of the experiment and Tables A.6 and A.7 the summary of partial results related with the two focuses of study.

Table A.5 Data sources used for the evaluation of the experiment with teachers and students and labels used in the text to quote them.

Data source	**Type of data**	**Labels**
Students' questionnaire about the exploratory phase *Discovering the district*	Qualitative numeric data, comments and opinions	[Q-st-route] (st, students)
Students' questionnaire about the whole experience (exploratory phase *Discovering the district* + presentations of the districts in phase *Reflect about you district*)	Qualitative numeric data, comments and opinions	[Q-st-final]
Teachers' questionnaire about the use of the QuesTInSitu application during the exploratory phase *Discovering the District*	Qualitative numeric data, comments and opinions	[Q-t-route] (t, teachers)
Teachers' questionnaire about the whole experience (exploratory phase + presentations of the districts)	Qualitative numeric data, comments and opinions	[Q-t-final]
Observations from 8 researchers external to the case of study about students' and teachers' behaviour during exploratory phase and during the presentations	Record of direct observations of student's behaviour during the route Record of direct observations of teachers' behaviour during the route Notes about students' opinion about the route and presentations	[Observations]
Videos of the students performing exploratory phase	Notes and observations transcribed from the videos	[Videos-route]
Videos of the students performing the presentations	Notes and observations transcribed from the videos	[Videos-presentation]
Presentations	Notes and observations obtained from the analysis of students' presentations	[Presentations]

Table A.6 Summary of findings and partial results related with the focus I.

Focus I. Added value and innovation of CSCBL script		
Findings	**Partial results**	**Support data**
1. The CSCBL scenario copes successfully with the limitations detected by the teachers in previous editions of the experience and entails new learning benefits.	- Students stress as the learning benefits of the *Visit the District* phase: 1) their freedom and active participation, 2) the dynamism of the activity, 3) learning about how to use a GPS, 4) the possibility of answering the questions in situ, which facilitates paying attention to the environment and better retaining the details of the contents 5) orientation skills acquisition, 6) learning and discovering new location, sociological characteristics, history and infrastructures *33/34 (97%) of the students indicated after the exploratory phase that they learnt new concepts about the districts* *28/34 (82%) of the students answered that they learnt more using the mobile in situ for answering the questions than filling in a dossier or doing an exam in class. 4/34 (12%) students indicated that they would have learnt more answering the questions in a dossier. 2/34 (6%) students did not answer this question* *6/34 (18%) students valued in a likert scale that their feeling of learning after doing the experience was 3/5 points. 23/34 (68%) students valued their learning experience with 4/5 points. 2/34 (6%) students valued with 5/5 points. 3/34 (8%) students did not answer the question* - Teachers point out that the exploratory phase: 1) reinforces students' autonomy, 2) allows students practice their spatial orientation and 3) helps students in the exploration and understanding of the urban space and its elements. - Teachers point out that the exploratory technology-enhanced activity (integrated as part of a learning flow through the CSCBL script) allows learning about more districts of the city compared with previous experiences. - The mobile phones with the automatic assessment feedback system helps students on being directly in contact with the environment, focussing the attention on the services and buildings in the area and reflecting about it.	Observations during the exploratory phase, presentations contents, students' and teachers' questionnaires about the exploratory phase and students' questionnaire about the whole experience, video presentations
2. Structured group activities integrated into the CSCBL scenario promote the collaboration and cooperation between students and developing teamwork skills. Also, the role-distribution during the exploratory phase as well as the pre-test district assignments policy is perceived by teachers and students as a successful mechanisms to structure collaboration.	- Students and teachers agree that the role distribution: 1) helps on the task distribution and on focusing on one unique task (*positive interdependence*), which is more effective for learning, 2) promotes active participation of all group members (individual accountability*)* and 3) helps on structuring, organizing and making the activity more dynamic, 4) promotes discussions (critical thinking), 5) facilitates decision making processes (communicative skills) and 6) enhances cooperation between group members. *34/34 (100%) All students answered that it has been helpful working in groups* - Organizing the exploratory phase through a sequence of questions promotes debates that make students' reflect and look for agreements (reflective and explorative learning). - Working directly in contact with the environment enhances student's interactions with people in the city making them to practice their communicative and social skills in situations they are not used to. - All students intervened in the presentations.	Observations during the exploratory and presentation phases, presentations contents, students' questionnaires about the exploratory phase and about the whole experience, teachers' questionnaire about the whole experience and video presentations.
3. Students' comments and observations evidence the CSCBL scenario as a motivating and innovative experience compared with similar ones.	Students use adjectives as innovative, different, interactive, dynamic, interesting and funny for describing the experience. *24/34 (71 %) students punctuated the exploratory experience with 4/5 points and 10/34 (29 %) students with 5/5 points* *All students (34/34 – 100%) and the two teachers indicated that they would repeat the activity another year for learning about a different district* - Students enjoyed working in groups and highlight this as one of the most positive aspects of the experience. - Students and teachers see the use of ICT as one of the innovative aspects compared with previous experiences. *31 students (out of 31, 100%) answered that they prefer these types of experiences in front of other similar experiences.*	Students' questionnaires about the exploratory phase and the whole activity, teachers questionnaires about exploratory phase

4. To combine exploratory activities with the presentation work into an integrated learning setting promotes students' reflection about concepts acquired in class and in other courses. Teachers also consider this integration necessary to provide a complete evaluation of the activity.	- Observations by experts and students highlight that they apply the contents worked in class during the exploratory phase. - Teachers stress that the exploratory-type of activities facilitate analyzing on the direct physical environments some of the course contents complementing what have been worked in class. - Teachers see the exploratory and the presentation phases complementary, which, integrated into the same learning setting, enable a complete evaluation of the students' outcomes. - Students complement the concepts worked during the exploratory phase with other information sources and the topics worked in class.	Observations during the exploratory and presentations phase, presentations contents, students' and teachers' questionnaires about the exploratory and about the whole experience

Table A.7 Summary of findings and partial results related with the focus II.

Focus II. Technological environment as a mechanism for supporting and facilitating students' and teachers' tasks		
Findings	**Partial results**	**Support data**
1. The mobile and GPS devices combined with the monitoring functionalities included in QuesTInSitu and the Moodle platform are perceived by the teachers as an easy and good support for controlling progress of the groups' activity during the whole activity and, in particular, during the exploratory phase.	- The teachers successfully followed at *runtime* the students' activity and their answers during the exploratory phase, which enable them to discuss about student's progress. Teachers qualify the monitoring functionality as one of the best functionalities provided by the QuestInSitu application and define it as very intuitive. - Teachers value the level of intuitiveness of the monitoring functionality with the higher mark (5 over 5). - Teachers value positively the whole tooling employed during the experience (Moodle, QuestInSitu and GPS Mobile Devices) and describe it as practical, functional, easy to understand, organized and clear.	Observations during the exploratory phase and teachers questionnaire about the exploratory phase
2. Mobile devices complemented with a map and the questions are a successful mechanism to organize, structure, support and guide the actions during the exploratory phase.	- Students highlight that mobile devices and the automatic assessment and feedback system are easy to use, useful and a structured and clear way to know which tasks to perform at anytime. Teachers highlight using the automatic assessment and feedback system with mobile devices as an interesting mechanism that helps on structuring the activity. *33/34 (97%) students indicated that the feedback helps them to know how to continue in the activity and their progress on it* The GPS and the maps complement the guidance provided by the feedback: *Students using GPS during the whole exploratory phase found the device a very useful guide. (*6 (out of 10) students using the GPS during the whole experience answered that they could have performed the activity without map.*) *Students from the Sant Marti Group (mixing activities with and without GPS) prefer the activity when it is supported by GPS because it is more interesting, practical and faster. *Students that did not use the GPS during the exploratory experience consider that the GPS was not necessary. However, they comment that it had been useful because they experienced some difficulties on finding some streets and interpreting the map.	Observations during the exploratory phase and the presentations, teachers' and students' questionnaires after the exploratory phase and after the whole experience
3. Students and teachers find the technology employed usable and appropriate for the experience. However, some technical problems were detected and some improvements suggested.	- Students prefer answering the questions in a mobile because it is easier than carrying a dossier with questions. *(32/34 (94%) answered that they preferred the mobile when they were asked to choose about using mobile phones, filling a dossier or doing an exam in class. Only 2/34 (6%) students indicated that they preferred a dossier)* - Although the students find the use of QuestInSitu easy to use (*33/34 (one did not answer this question) answered that mobile phone QuesTInSitu application was very easy to use*), some usability problems were detected by the students when using the mobile devices: *Visualization and interactive problems with the tactile screen* *The GPS does not always work properly and is very slow. However, students don't experiment problems resetting the device and launching again the application in case of error.* - Observations and teachers' answers highlight that the monitoring system could be improved by adding system to visualize and talk to the students at *runtime* and the final mark of the test.	Students' questionnaires about the exploratory phase and the whole activity, teachers questionnaires about exploratory phase